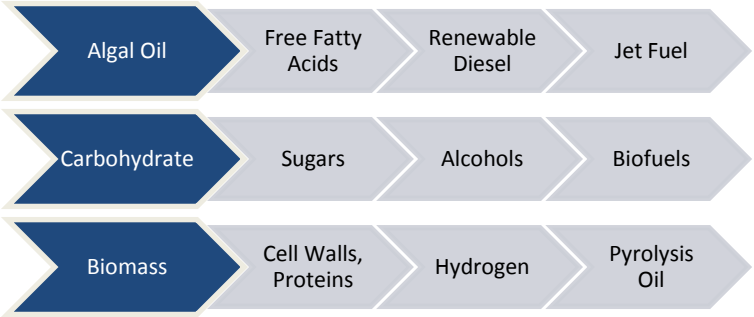
Biofuels: The Potential of Algae

Most algae are single-celled organisms that grow in either marine (saltwater) or freshwater environments. Most strains are photosynthetic and represent the world's fastest growing plants. Like other plants, they convert sunlight, water, CO_2, and other nutrients into energy and biomass and release large amounts of oxygen into the atmosphere. A number of algae strains and marine organisms derive energy from organic carbon, rather than atmospheric carbon (through photosyntesis. There are over 65,000 known species of algae, including many different varieties such as red, green, brown, and blue-green (cyanobacteria).

Potential Pathways to Biofuels

Algae are already important in numerous commercial uses: to produce nutritional supplements, to treat sewage, and as coloring agents. One of the most promising uses of algae is as renewable raw material for biofuels. The vegetable oil from algae can be used directly (straight vegetable oil that is esterized into biodiesel) or refined into various biofuels, including renewable diesel and jet fuel, in addition to other chemical ingredients for products such as cosmetics. The carbohydrates (sugars) from algae can be fermented to make additional biofuels, including ethanol and butanol, as well as other products such as plastics and biochemicals. Biomass from algae can be used for pyrolysis oil or combined heat and power generation.



Algae-derived renewable diesels and jet fuels are drop-in fuels that directly replace petroleum fuels without modification of engines. They meet all the specifications for the petroleum fuel they replace.

Advantages for Biofuels

Algae are renewable resources for biofuels that can be grown on non-arable lands, using saltwater or brackish water. A significant advantage of using algae for biofuels is that it need not displace farmland used for growing food sources. The Department of Energy reports that algae have the potential to yield at least 30 times more energy than land-based crops currently used to produce biofuels.

Algae also efficiently recycle atmospheric carbon. While algae comprise less than 2 percent of global plant carbon, they absorb and fix up to 50 percent of atmospheric carbon dioxide(30 billion to 50 billion metric tons per year), converting it to organic carbon. Through photosynthesis, they produce up to 50 percent of global oxygen. The Environmental Protection Agency estimates that algae-based biodiesel produced through fatty acid methyl transesterification (the only type of algae biofuel modeled to date) can reduce greenhouse gas emissions by more than 60 percent compared to petroleum diesel.

Commercial Development

Biofuel companies are currently seeking to scale commercial production of algae and are pursuing several engineering approaches to the design of an economical system for growing algae. Companies are investigating use of closed systems and open pond systems. In closed systems, engineers can precisely regulate algae growth conditions. Closed systems include both photobioreactors for photosynthetic algae strains and traditional bioreactors (enclosed tanks such as those used in other microbial growth) for those, such as cyanobacteria, that do not require sunlight. Open pond systems have been used in many settings, but can be sensitive to various environmental factors, such as contamination by other algae strains, or variations in nutrients, heat and light. Pond systems covered by thin plastic films and combination closed/open systems are being developed to control these factors.

The Defense Advanced Research Projects Agency is working with teams led by Science Applications International Corp. (SAIC) and General Atomics to produce cost-effective military jet fuel (JP-8) from algae. Testing is expected to begin in 2011. The Navy's Defense Energy Support Center has also purchased and begun testing algae-derived diesel distillates from Solazyme. And Continental Airlines and Japan Airlines have successfully tested Jet A from Sapphire Energy and UOP Renewables in commercial jets, including Boeing 737 and 747 planes.

Industrial Research & Development

Currently, many BIO Member Companies are focused on research in this area. Some companies include:

Company	Facility Location	Capacity (GPY)	Start Date
Algae2Omega	Ft. Lauderdale, Fla.	500,000	
Algenol	Lee County, Fla.	100,000	2012
Algenol - Dow Chemical Co.	Freeport, Texas	100,000	2012
Aurora Biofuels	Coastal Florida	1,000	Aug. 2007
Cape Cod Algae Biorefinery	Massachusetts Military Reservation, Bourne, Mass.	1 million	Fall 2010
Cellana (Shell - HR BioPetroleum)	Kona Pilot Facility (KPF), Kona, Hi.		2010

Culturing Solutions	Phyta-Pond Type II PhotoBioreactor, Tampa, Fla.	500,000	
HR BioPetroleum, Inc.	Ma'alaea, Maui, Hi.		
Inventure	Seattle, Wash.		
Joule Biotechnologies	Leander, Texas		June 2010
LiveFuels, Inc.	Brownsville, Texas		Aug. 2009
PetroAlgae	Fellsmere, Fla.		
Phycal	Honolulu, Hawaii		Dec. 2010
Sapphire Energy	Columbus, N.M.	1 million	
Solazyme	Danville, Pa.		
Solix Biofuel	Coyote Gulch Demonstration Facility Durango, Colo.	6,000	July 2009
US Biofuels	Fresno, Calif.	4 million	Dec. 2010